Language Co-Activation in Novice and Intermediate L2 Learners

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LANGUAGE CO-ACTIVATION IN NOVICE AND INTERMEDIATE L2 LEARNERS

by

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ABSTRACT

One of the most intriguing aspects of bilingual speakers and signers is their ability to access both languages simultaneously. Though much research has been dedicated to understanding how two languages interact, or co-activate, within proficient bilinguals, less is understood about how and when novice and intermediate learners develop similar cross-language interactions. Thus, the current study aimed to uncover at what stages during novice and intermediate L2 development co-activation can be detected. It also investigated possible mechanisms behind co-activation. Specifically, the study attempted to clarify if any detected co-activation amongst L2 learners is dependent on associations between lexical and conceptual representations, or, rather, if co-activation relies primarily on lateral lexical links without conceptual mediation. These questions were tested with native English-speaking novice and intermediate learners of Spanish at the University of New Mexico. Participants partook in three online experiments across two sessions: lexical decision tasks in both the L1 and the L2, and a translation recognition task similar to Sunderman & Kroll (2006) and Ma et al. (2017). While significant L2-on-L1 effects were not found, the current study did uncover that participants experienced significant increases in L2 word knowledge across sessions. Furthermore, evidence of direct L2 meaning access was also found, even in less proficient participants.
# TABLE OF CONTENTS

LIST OF FIGURES ......................................................................................................................... vi

LIST OF TABLES .............................................................................................................................. vii

CHAPTER 1 INTRODUCTION ........................................................................................................... 1

CHAPTER 2 BACKGROUND ............................................................................................................... 5

Historical Background ................................................................................................................. 5

L2 Meaning Access and Co-A ctivation ...................................................................................... 7

CHAPTER 3 METHODOLOGY .......................................................................................................... 12

Participants .................................................................................................................................. 13

Participant Grouping ................................................................................................................ 17

Materials and Design ................................................................................................................ 18

Procedure ................................................................................................................................... 21

Analysis ....................................................................................................................................... 22

CHAPTER 4 RESULTS .................................................................................................................. 24

Verbal Fluency Task (English) ................................................................................................. 24

Verbal Fluency Task (Spanish) .............................................................................................. 24

Spanish Lexical Decision Task ............................................................................................... 25

Repetition Effects ..................................................................................................................... 26

Translation Recognition Task ................................................................................................. 28
CHAPTER 5 DISCUSSION ................................................................. 39

Spanish Lexical Decision Task .................................................... 39

Translation Recognition Task ..................................................... 41

English Lexical Decision Task .................................................... 44

Sensitivity with d’ .......................................................................... 46

Limitations and Future Studies .................................................... 48

Conclusion ................................................................................... 51

APPENDICES ................................................................................ 52

APPENDIX A LANGUAGE BACKGROUND QUESTIONNAIRE ....... 52

REFERENCES .............................................................................. 58
LIST OF FIGURES

Figure 1. Spanish I (First Semester) Exposure Percentages. .............................................14

Figure 2. Spanish III (Third Semester) Exposure Percentages. ......................................15

Figure 3. ACTFL Proficiency Distribution........................................................................17

Figure 4. Spanish LDT Cross Session d’ Scores. ............................................................37

Figure 5. English LDT Cross Session d’ Scores...............................................................38
LIST OF TABLES

Table 1. Mean (and SD) for properties of Spanish Stimuli ........................................21

Table 2. Mean (and SD) exemplars produced in English across categories .................24

Table 3. Mean (and SD) exemplars produced in Spanish across categories .............25

Table 4. Mean Accuracy and Reaction Times (ms) and SD for the Spanish LDT ........26

Table 5. Estimated Coefficients from the Spanish LDT Mixed Model-RT .................27

Table 6. Estimated Coefficients from the Spanish LDT Mixed Model-Accuracy ........27

Table 7. Mean RTs, Accuracy, and SDs for the TRT (Less proficient) ....................29

Table 8. Mean RTs, Accuracy, and SDs for the TRT (More proficient) ...................29

Table 9. Estimated Coefficients from the TRT Mixed Model on RT. Form-Model ....31

Table 10. Estimated Coefficients from the TRT Mixed Model on RT (ms). Semantic-Model. ........................................................................................................................................................................32

Table 11. Mean Accuracy and Reaction Times (ms) and SD for the English LDT ......33

Table 12. Effect of L2 Word Knowledge on L1 Word Retrieval (Less Proficient) ......34

Table 13. Effect of L2 Word Knowledge on L1 Word Retrieval (More Proficient) ...35

Table 14. Estimated Coefficients from the English LDT Mixed Model on Accuracy
Chapter 1

Introduction

Over the past several decades, bilingualism has become one of the most popular and interesting topics of research within the scientific community. Bilinguals’ ability to learn, comprehend, utilize, and manage two languages provides captivating insights into the processing and cognitive capabilities of the human brain. One of the most intriguing aspects of bilingual speakers and signers is their ability to access both languages simultaneously. Even more intriguing, however, is that bilinguals’ two languages can be accessed, or co-activated, even in contexts in which only one language is in use (Hermans et al. 1998; Costa et al., 2000; Acenas & Gollan 2004; Marian et al. 2008). Investigation of this phenomenon has revealed captivating new insights into the bilingual lexicon as well as cultivated several enduring questions that remain unanswered. One of these questions, which is central to the current study, is: to what extent do less proficient L2 learners experience bi-directional language co-activation during L2 development?

Despite the magnitude of studies that have been carried out on bilingual lexical processing, much remains to be uncovered. One population of bilinguals that has received far less attention with respect to language coactivation concerns bilinguals at novice and intermediate proficiency levels. Several behavioral studies on both children and adults (Costa et al., 2000; Van Hell & Dijkstra 2002; Poarch & Van Hell 2012; Dimitropoulou et al. 2011) have demonstrated that novice L2 learners display an asymmetric co-activation relationship between languages; meaning, the L1 has stronger effects on the L2 than the reverse. This evidence suggests that while the more dominant L1 elicits strong effects on the L2, a certain level of L2 proficiency is required to observe significant effects of the L2 on the L1.
Intrinsic to language co-activation in L2 learners is the interplay between L1 and L2 proficiency. As mentioned above, the role of the dominant L1 during L2 learning has been shown to result in an asymmetric relationship but increasing L2 proficiency seems to give rise to a more bi-directional relationship (Poarch & Van Hell 2012; Dimitropoulou et al. 2011). Recent studies by Bice and Kroll (2015) and Higby et al. (2019) have further explored this idea and have found evidence of bidirectional co-activation in novice L2 learners. The results from these studies, discussed in chapter two, suggest that L2 learning can impact the L1 even during the earliest stages of L2 development.

While L2-on-L1 effects appear possible amongst L2 learners, the extent to which these effects occur, especially in novice learners, remains unclear. The current study aims to uncover if these bi-directional interactions are indeed found in college students enrolled in their first semester of post-secondary second language courses, and, furthermore, to investigate the mechanisms driving such interactions. Proficiency appears to be a well-known predictor of language co-activation – higher proficiency results in higher levels of co-activation. However, it is unclear which aspect(s) of high proficiency result in such interactions. In the current study, we aim to investigate one of the many possible mechanisms behind co-activation: direct L2 access to meaning. The Revised Hierarchical Model (Kroll & Stewart 1994) was the first model to propose that meaning access depends on L2 proficiency. L2 learners in early stages of acquisition utilize direct lexical links from L2 to L1 to access meaning during translation production and recognition. This claim has been extensively debated. While the RHM originally claimed that L1 mediation is necessary for meaning access in the L2, others, like Brysbaert & Duyck (2010), have countered that meaning access is possible for L2 learners early during development, suggesting that L1 mediation via lateral lexical links is not as necessary as previously thought. This critique to the RHM was responded to by Kroll et
al. (2010), who agreed that the RHM’s early assumption that L1 mediation was necessary for *comprehending* the meaning of an L2 word was incorrect. However, Kroll et al. (2010) note an important distinction that is absent from Brysbaert & Duyck’s critique: learners at lower proficiencies, who appear able to directly access meaning in word recognition and comprehension tasks, are unable to reliably lexicalize concepts into L2 words in production. Thus, access from words to concepts may be more easily achieved for some learners (comprehension), while access from concepts to words may be more effortful (production). This clarification is important in relation to the current study, which primarily investigates language comprehension in L2 learners, rather than production. Recently, a study by Ma et. al (2017) utilized behavioral measures and event-related potentials(ERPs) to investigate the necessity of L1 mediation during L2 meaning access. They found that less-proficient L2 learners were able to access L2 meaning without the mediation of the L1 during comprehension. While these studies do not directly investigate L2-on-L1 interactions, they do provide important claims regarding L2 access to meaning and the avenue taken during meaning access. We believe these paths of lexical access during comprehension – L1 mediation as proposed by Kroll & Stewart (1994) and direct L2 meaning access as proposed by Brysbaert & Duyck (2010; cf. Ma et al. 2017) merit further investigation in the context of language co-activation. By clarifying the path by which less proficient L2 learners access meaning, we will be able to measure the extent to which one, or both, of these paths influence L2-on-L1 effects, thus providing more insight into the driving forces behind the development of facilitatory L2-on-L1 interactions in these learners. Thus, our second research question is: *Does direct L2 meaning access act as a prerequisite for observable L2-on-L1 effects? Or can L2 knowledge influence L1 processing even when L2 learners rely primarily on direct lexical level links?*
Based on the neural and behavioral evidence above, it appears probable that an L2 in early stages of development can have subtle effects on L1 processing. Less clear, however, is our current understanding of which mechanisms can influence bidirectional co-activation, and at what stages during novice and intermediate L2 development such influences can be detected. Thus, the current study aims to explore the extent of and motivation behind these cross-language interactions in novice and intermediate L2 learners.
Chapter 2

Background

**Historical Background**

The bilingual lexicon and language co-activation have been dominant topics of interest in the linguistic community for the past several decades. The fascinating interplay between two or more languages has motivated science and scientists alike. However, before the relatively recent increase in attention, the bilingual lexicon was viewed in quite a different light almost a century ago:

“When two languages come to be spoken by the same society for the same purposes, both of these languages are certain to deteriorate. The sense of conflict disturbs in both of them the basis of articulation, deranges the procedure of grammar, and imperils the integrity of thought. The representation of the mind is divided into incongruous halves; and the average speaker, being no linguistic expert, finds it difficult to keep the two media apart. Confusion follows. The contours of language grow dim as the two systems collide and intermingle” (Roberts 1939: 23).

Unfortunately, assumptions like this were somewhat common in the early 20th century. Bilingualism was conceived as an impediment rather than the benefit it is seen as today. Common misconceptions were that bilinguals experience confusion due to the presence of their two languages and that the interactions of these two language systems lead to deterioration (Roberts 1939). However, as scientific inquiry and technology expanded, assumptions like the one described above were falsified.

As the 20th century continued, the interest in the bilingual lexicon continued and expanded in parallel. In the mid-20th century, the bilingual’s two languages were conceptualized as separated within the bilingual lexicon (Kolers 1963). Over time, this idea transitioned into the assumption that bilinguals have a shared conceptual bank while lexical items continued to be separated (Kolers 1968). In the latter quarter of the 20th century, interest in the bilingual lexicon rose to new heights, resulting in a surge in
creation of theories and theoretical models which aimed to explain the complexity of interaction within the bilingual mind. Two such models were the Word Association Model (WAM) and the Concept Mediation Model (CMM) created by Potter et al. (1984). While Potter et al. did not strictly advocate that these models could account for a wide range of data on bilingual language production, these models encompassed two theoretical alternatives that sparked interest in the bilingual lexicon. As precursors to the RHM (Kroll & Stewart 1994), the WAM and CMM predicted separate hypotheses regarding word translation and picture naming in two languages. First, the WAM proposed that a direct link is established between words in the two languages (Potter et al. 1984). During second language acquisition, that association is used to retrieve and produce words in the second language by accessing the word in the first language. Second, the CMM proposed that the only connection between languages is via an amodel conceptual system, one to which pictured objects also have access (Potter et al. 1984). After testing both hypotheses using several picture naming, word naming, and translation tasks, Potter et al. concluded that their results were more consistent with the CM hypothesis; their results contradicted predictions of the WAM. While no evidence was found for the WAM, the idea that words may be directly associated between languages was not entirely discarded. In 1994, the Revised Hierarchical Model (Kroll & Stewart 1994) sought to combine hypotheses from both the WAM and CMM. The result was a model of the bilingual lexicon that continues to influence research to this day.

Central to the current study is the widely cited Revised Hierarchical Model (Kroll & Stewart 1994). The RHM predicts that L2 learners in early stages of acquisition utilize direct lexical links from L2 to L1 during translation production. Thus, novice learners of an L2 must reach a certain proficiency level before direct L2 meaning access is possible. Although the RHM is primarily a model of word production more so than recognition, the
model’s central claims, one regarding language asymmetry and the other L2 learning history (Kroll et al. 2010), are directly applicable to language comprehension as well.

In summary, the bilingual lexicon has become a hugely popular topic of scientific interest over the past several decades. As past assumptions were falsified, new intrigue resulted in several theories and models of bilingual lexical access. While new theories and models continue to be generated to this day (Shook & Marian 2013; Dijkstra et al. 2019), the model central to the current study is the RHM (Kroll & Stewart 1994). The following section will discuss L2 meaning access, an integral part of bilingual lexical processing, and its relationship to language co-activation, the primary topic of the current study.

**L2 Meaning Access and Co-Activation**

Access to L2 meaning in highly proficient bilinguals is an essential mechanism of bilingual lexical access. Countless research has demonstrated that L2 access to meaning drives translation recognition and production (Kroll & Stewart, 1994), cognate facilitation (Costa et al. 2000), TOT states (Gollan & Acenas 2004), and cross-language semantic interference (Hermans et al. 1998; Poarch et al. 2016). Additionally, it has been shown that the strength of this connection is dependent on several factors, including proficiency (Kroll & Stewart 1994; Dijkstra et al. 2019) and L2 frequency of use (Duyck et al. 2008). However, despite the consensus regarding the importance of direct L2 meaning access, it remains unclear to what extent it can influence co-activation during word retrieval, especially for novice and intermediate L2 learners.

According to the RHM, there are two avenues by which language learners access meaning in their L2: via L1 mediation and direct L2 meaning access. As mentioned above, Kroll & Stewart (1994) theorized that, during language production in early stages of development, L1 mediation is necessary while direct L2 meaning access becomes
available as proficiency rises. Although this may be the case during L2 production, L2 meaning access has been argued to be more readily available during L2 comprehension (Brysbaert & Duyck 2010). Recent evidence from Ma et al. (2017) has supported this claim.

In their 2017 study, Ma et al. tested claims made by the RHM. Specifically, they tested the role of the L1 translation equivalent during L2 meaning access with university-age native English learners of Spanish. Centered around claims made by the RHM, Ma et al. utilized behavioral and ERP data to measure reliance on L1 translation equivalents and direct L2 meaning access. Participants were asked to participate in a translation recognition task and were told to reject distractors that were related in form to the L1 translation equivalent (gato, cap) and distractors that were related semantically to the L1 translation equivalent (gato, dog). Behavioral data revealed both semantic and translation interference. ERP data showed that a larger P200, a smaller N400, and a larger LPC (late positive complex) were elicited by semantic distractors (Ma et al. 2017). These results indicate that even less proficient learners can access L2 meaning without L1 mediation during language comprehension, supporting previous findings from Guo et al. (2012). These results are consistent with the theory that less proficient learners can access L2 meaning directly during comprehension. While L1 mediation is predicted to be more necessary during production (Kroll et al. 2010), accessing meaning without such mediation is more readily available during comprehension. This asymmetry is illustrated by the ERP data in the Ma et al. study – participants displayed sensitivity to semantic word pairs at early SOAs, but the same sensitivity was not captured from the translation-form pairs, indicating that the participants were able to access L2 meaning directly without mediation though the L1.
According to this evidence, direct L2 meaning access appears possible in less proficient learners. However, are L2-on-L1 effects similarly possible? As mentioned previously, several past studies have demonstrated that less proficient learners display an asymmetric relationship between languages (Costa et al., 2000; Van Hell & Dijkstra 2002; Poarch & Van Hell 2012; Dimitropoulou et al. 2011), which makes these bidirectional effects seemingly unlikely. However, recent studies have shown that, despite this asymmetry, less proficient L2 learners do in fact experience co-activation and even facilitation (Bice & Kroll 2015; Higby et al. 2019). Words known in the L2 (Higby et al. 2019) as well as cognates (Bice & Kroll 2015) have been found to be co-activated during L1 processing, resulting in facilitated retrieval of L1 words. While these L2 words are not being actively used, they continue to affect L1 processing, thus illustrating language co-activation.

In their 2015 study, Bice and Kroll questioned whether L1 changes can be detected at early stages of L2 learning. Native English speakers learning Spanish participated in a lexical decision task (LDT) while event-related potentials were recorded. Their findings revealed that intermediate Spanish learners demonstrated a reduced N400 for cognates compared with noncognates in the L1, English. Furthermore, an emerging, though less established effect was visually present in beginning learners as well. In their 2019 study, Higby et al. investigated L2 vocabulary interference in L1 picture naming in late Portuguese-English bilinguals. Contrary to prior studies reporting interference, results demonstrated that words known in the L2 facilitated naming in the L1. They propose that an L2 may facilitate L1 lexical retrieval via an indirect frequency boost from known translation equivalents. These results suggest that L2 learning can impact the L1 during early stages of L2 development.
These recent studies have demonstrated some remarkable findings: direct L2 meaning access, as well as L2-on-L1 effects resulting in facilitation, are possible in less proficient L2 learners. However, two main ideas remain unclear. First, to what extent are these two linguistic phenomena related? Specifically, is direct L2 meaning access required to incite L2-on-L1 effects? Can L2-on-L1 effects occur without this theorized mechanism? Or, can one occur separately from the other? Second, while these past studies have uncovered new evidence of these interactions in less proficient learners, several of the participants in these studies display or self-report proficiency levels which indicate L2 development past the Novice Proficiency Level (ACTFL 2012). In Higby et al. (2019), participants (late L2 English learners) self-rated their listening comprehension at a mean of 4.56/7. University Spanish learners in Ma et al. (2017) self-rated their Spanish proficiency at a mean of 6.39/10. Only the study conducted by Bice & Kroll (2015) contained a beginning learner category which entailed university Spanish L2 learners with a (lower) mean self-rating score of 4.7/10; these learners only displayed an emerging, less established effect during experimentation. Thus, despite the evidence supporting both direct L2 meaning access and L2-on-L1 effects in ‘less proficient’ learners, it remains unclear if similar evidence can be found amongst learners in the earliest stages of L2 development. Furthermore, due to the lack of longitudinal studies in this area of research, it is not yet clear when L2 learners begin to develop these interactions during the acquisition process.

For these reasons, the current study investigates direct L2 meaning access and L2-on-L1 effects in participants at varying proficiency levels at two points across an academic semester. As novice and intermediate learners of a second language, these participants are actively moving through important developmental stages of acquisition, acquiring new words, and creating lexical connections. Although recent evidence from
Poarch, Van Hell, and Kroll (2016) has demonstrated that early direct L2 meaning access is possible, learners often will not immediately establish these connections, due to the asymmetry of their two languages. This developmental step presents a window of opportunity: we may investigate the mechanism behind language co-activation before direct L2 meaning access is typically possible. In this way, we may clarify the importance of conceptual mediation as a prerequisite to incite facilitatory cross-language effects. Additionally, we can measure if lateral lexical links (Gollan et al. 2005; Sunderman & Kroll 2006; Dylman & Barry 2018), established early in L2 development (Kroll & Stewart 1994), suffice to boost activation of L1 words.
Chapter 3

Methodology

The present study aims to extend research of L2 meaning access and bi-directional language coactivation in novice and intermediate L2 learners. As these L2 learners increase in proficiency, we predict that they are more likely to experience facilitation of reaction time when retrieving words in the L1 for which they know the L2 translation equivalent. This prediction is more likely to be visible with the intermediate learners, who have shown more salient results due to their high knowledge of L2 words (Bice & Kroll 2015). Furthermore, we expect similar findings to Ma et al. (2017); if novice and intermediate learners are accessing meaning directly from L2 word forms, semantically related distractors are expected to elicit inhibition during translation recognition (gato, dog). Our two research questions, mentioned earlier in the text, are repeated below:

**Research Question 1**: To what extent do less proficient L2 learners experience facilitatory bi-directional language co-activation during L2 development? Will L2-on-L1 effects be observable during comprehension?

**Research Question 2**: Does direct L2 meaning access act as a prerequisite for observable L2-on-L1 effects? Or can L2 knowledge influence L1 processing even when L2 learners rely primarily on direct lexical level links?

The present study consists of a series of three online experiments – an English Lexical Decision Task, Spanish Lexical Decision Task, and a Translation Recognition Task adapted from Ma et al. (2017). These three experiments were completed in succession by the participants and repeated again four weeks later during the semester. Detailed sections on the participants, materials, procedure, and data analysis will be presented below.
Participants

Twenty-two native English speakers, one native Arabic speaker, and one native Nepali speaker (18 female, 21.5±5.5 years) from the University of New Mexico participated in the study. Three (3 female, 24±5.3 years) were English-ASL bilinguals with no prior Spanish experience. These participants acted as the control group. Six (3 female, 20.5±2.5 years) were enrolled in a third semester Spanish course. Fifteen (12 female, 21.5±6.4 years) were enrolled in a first semester Spanish course. The two non-native speakers of English were not excluded from the study because they reported primarily using English in all educational settings and with at least one parent/guardian during childhood. All participants completed a language background questionnaire adapted from Giráldez Elizo (2020). This questionnaire provided information on participants’ language background, exposure, and subjective proficiency. The questionnaire can be found in Appendix A.

Twelve participants reported studying languages other than Spanish; these languages included French, Mandarin, German, Hebrew, Japanese, ASL, and English. Three participants reported using Spanish on a regular basis. None of the participants had ever studied abroad nor had they participated in a bilingual education or immersion program. The primary language spoken by the parents and guardians of the participants was English (90% SD 6%). Only one participant reported Spanish being spoken by a guardian. Seven of the Spanish learners reported that they spoke Spanish with friends, partners, and/or community members.

Most (80%) of the first semester participants reported that they had little exposure to Spanish words between ages 0 and 10 (see Figure 1). However, after the age of 10, 33% of students reported that they were sometimes (25%) exposed to Spanish words.
83% of Spanish III participants reported that they had little exposure to Spanish words between the ages of 0 and 6 (See Figure 2). Like the Spanish I participants, Spanish III participants reported an increase in exposure to Spanish words after the age of 10. 50% reported they were sometimes (25%) exposed to Spanish words between the ages of 6 and 13. After the age of 13, 83% of students reported being exposed to Spanish sometimes (25%). It is interesting to note that none of the Spanish III participants reported ever being exposed to Spanish words over half of the time (50%). Upon comparison, both groups of learners show little Spanish exposure early during childhood. Both groups show an increase in exposure after the age of 10.
Participants self-rated their Spanish proficiency by answering twenty questions adapted from the NCSSFL-ACTFL Can-Do Statements (ACTFL 2012). Each of the following five ACTFL proficiency levels were represented by four questions: Novice-Mid, Novice-High, Intermediate-Low, Intermediate-Mid, and Intermediate-High. Each participant responded to statements like “I can ask for directions when I am lost” with one of the following answers: Yes, I can do this with confidence, Yes, I can do this, or I still need to work on this. Each question can be viewed at the end of the Language Background Questionnaire in Appendix 1.

As mentioned above, each sub-level of proficiency had a total of 4 statements. A participant was awarded a level of proficiency if 3 out of 4 statements (75%) corresponded to a Yes, I can do this or Yes, I can do this with confidence. This process continued up the proficiency scale for each individual participant until they could not reach the 75% benchmark. Once the participant reached less than 3 out of 4 statements,
they were assigned to the previous proficiency sub-level to which they reached 3 out of 4 successfully. An example of this process is shown below:

**Participant 1: Scored 4/4 in Novice-Mid and 3/4 in Novice-High. However, they only scored 2/4 in Intermediate-Low, and was thus assigned to the Novice-High Proficiency Level.**

Twelve (80%) of the first semester participants reported proficiency below the intermediate level (10 at Novice-Mid and 2 at Novice-High), while three participants reported proficiency at or above the Intermediate-Low level (see Figure 3). As expected, the majority report lower proficiency levels. However, three do report intermediate level proficiency. These three participants reported that they had not studied abroad nor been a part of a bilingual immersion program. Furthermore, all three reported to have grown up speaking English with family members and guardians. However, one noteworthy pattern is that all three of the participants who reported intermediate proficiency also reported that they used Spanish or Spanish and English with friends and community members on a day-to-day basis. Only one other first semester participant (at Novice-High) also reported that they used Spanish on a day-to-day basis.

The majority of third semester participants (66%) reported proficiency below the intermediate level (2 at Novice-Mid and 2 at Novice-High), while the remaining two participants reported an Intermediate-High proficiency level (see Figure 3). None of the third semester participants reported that they have studied abroad or been a part of a bilingual immersion program. While the unexpected distribution of proficiency amongst the third semester participants may be a result of sample size (6 participants as compared to the 15 in first semester Spanish), it is not surprising that many of these participants report novice proficiency. A recent survey by Lusin (2012) found that reaching the
intermediate proficiency level is challenging at the post-secondary level; only in institutions that require two full years of language study do successful learners begin to reach intermediate proficiency levels. The participants at the third semester level enter the class with the equivalent of one year of post-secondary Spanish course experience. Thus, it is not surprising that many of these learners have yet to reach intermediate levels of proficiency.

**Participant Grouping.** Due to varying levels of proficiency within each group, it was decided that participants were not to be categorized by course. Rather, participants were re-categorized into two groups (less proficient and more proficient) based on their Spanish Verbal Fluency scores. Unfortunately, 4 participants did not successfully complete the verbal fluency task. Thus, these participants were assigned to the group that corresponded to their course level. The remaining 17 were categorized using the overall mean score (5.1) on the Verbal Fluency Task; participants with a score above 5.1 were categorized as more proficient (n=7) and those with a score below 5.1 were categorized as less proficient (n=14).

**Figure 3 ACTFL Proficiency Distribution**
Materials and Design

Online Format and Data Security. Participants completed all three tasks across both sessions on the FindingFive Program (Finding Five 2019). FindingFive is a standalone online platform used to design and carry out online behavioral studies. This online structure enabled data collection to continue safely during the COVID-19 pandemic; participants were able to complete both sessions from the comfort and safety of their own home. While the online structure has many benefits, it is still a (somewhat) novel tool, containing several methodological weaknesses. One such weakness that must be addressed is its lack of precision due to latency issues. Specifically, during an experiment, a participant can experience lag or disconnection due to internet speed. Luckily, FindingFive marks any data collected during such lags or disconnects, making removal from the results very easy. Secondly, RT measurements in this modality are obviously far less precise than studies carried out in a laboratory setting. A comparison of the results from this completely online study will be compared to prior studies carried out in a typical laboratory setting in order to evaluate their comparability. Regarding data security, FindingFive uses HTTPS for all activities taking place on the platform. This means that all data are transmitted in encrypted forms over the internet. These encryption methods are state-of-the-art and pose minimal risk in leaking participants’ data.

Verbal Fluency Task. In this task, participants were asked to type as many exemplars as possible for specific semantic categories within a 60 second time limit. Exemplars were coded if the word provided was a word in the correct language and if the word belonged to the correct semantic category. Verbal fluency performance was analyzed by averages the total number of exemplars produced across categories. The task included eight
categories which were evenly distributed between language blocks (English and Spanish). The categories were vegetables, animals, body parts, family members, fruits, colors, school supplies, and musical instruments. This task had two goals. First, it aimed to provide a continuous measure of proficiency. This continuous measure helped categorize learners into less proficient and more proficient groups. Second, it aimed to uncover any repetition effects that could occur across sessions.

**English Lexical Decision Task (LDT).** In this task, participants were asked to respond as quickly and accurately as possible, using a key press, to whether a word presented on the screen is a real word in English, or not. Participants were presented with 36 English nouns (mean length = 4.80, SD = 1.2) and 36 non-words (mean length = 5.08, SD = 0.8), and 10 practice trials. English-Spanish cognates were not included. A trial began with a 500ms fixation cross (“+”) which appeared in the middle of the participants’ screen. After the fixation cross, participants were presented with one of the 72 stimuli in random order. Instructions were to “respond as quickly and accurately as possible, using a key press, to whether a word presented on the screen is a real word in English, or not”. Accuracy and RT data were collected. A response was considered inaccurate if it did not match the intended response. RTs that were associated with inaccurate responses or that were either below 250 ms or above 2000 ms were excluded from analysis.

**Spanish Lexical Decision Task (LDT).** In this task, participants were asked to respond as quickly and accurately as possible, using a key press, to whether a word presented on the screen is a real word in Spanish, or not. Participants were presented with 36 Spanish nouns (mean length = 5.40, SD = 1.2, mean (L1) Spanish frequency 228.8 from Clearpond (Marian et al. 2012) and SUBTLEX ESP (Cuetos et al. 2012), SD = 254.5) and 36 non-words (mean length = 5.25, SD = 1.3), and 10 practice trials. The 36 Spanish words were the translation equivalents of the 36 English words from the English LDT.
English-Spanish cognates were not included. A trial began with a 500ms fixation cross (“+”) which appeared in the middle of the participants’ screen. After the fixation cross, participants were presented with one of the 72 stimuli in random order. Instructions were to “respond as quickly and accurately as possible, using a key press, to whether a word presented on the screen is a real word in Spanish, or not”. Accuracy and RT data were collected. A response was considered inaccurate if it did not match the intended response. RTs that were associated with inaccurate responses or that were either below 250 ms or above 2000 ms were excluded from analysis.

**Translation Recognition Task.** This task was adapted from Ma et al. (2017). Three hundred and twenty Spanish-English word pairs were built for this task, with a Spanish word presented prior to an English word in each pair. Among these, 160 were correct translation pairs (YES trials). The YES trials included the 36 words used in the Spanish LDT and 124 YES filler pairs, resulting in 160 total correct translation pairs. The remaining 160 pairs were incorrect translation pairs (NO trials) which were equally divided into four conditions: semantically related, semantically unrelated, translation-form related, and translation-form unrelated. The 36 words used in the Spanish LDT were also included in these incorrect translation pairs. For semantically related trials, the Spanish and English words were related in meaning (e.g., gato, dog), whereas for semantically unrelated trials the two words were not related in meaning (e.g., gato, book). The translation-form related trial was when the English word resembled the English translation equivalent of the Spanish word in form and/or phonology (e.g., gato, cap; cap and cat are similar in form). The translation-form unrelated trial was when the word pairs were not related in form or meaning (e.g., gato, light; light and cat are not similar in form). Spanish-English cognates were excluded. The English words in the four conditions were matched on frequency and there were no significant differences in word frequency.
between groups of stimuli, \((t < 1, p > 0.05)\). Additionally, word length was not significantly different between the semantically related/unrelated words or the translation-form related/unrelated words, \((t < 1, p > 0.05)\).

Table 1 gives the properties of the Spanish stimuli. RTs that were associated with inaccurate responses or that were either below 250 ms or above 2000 ms were excluded from analysis.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency</th>
<th>Word Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantically Related</td>
<td>50.98 (63.4)</td>
<td>6.10 (1.8)</td>
</tr>
<tr>
<td>Semantically Unrelated</td>
<td>55.70 (68.1)</td>
<td>5.95 (1.6)</td>
</tr>
<tr>
<td>Translation-Form Related</td>
<td>71.56 (140.9)</td>
<td>4.55 (0.9)</td>
</tr>
<tr>
<td>Translation-Form Unrelated</td>
<td>73.31 (147.2)</td>
<td>4.53 (0.9)</td>
</tr>
</tbody>
</table>

Note: Spanish word frequency and length were compiled from both the Clearpond (Marian et al. 2012) and SUBTLEX-ESP (Cuetos et al. 2012) databases. Both databases were used because no one database had all required words.

Procedure

All tasks were completed remotely on the participants’ personal computer. First, the participants completed the language background questionnaire located on the Google Survey Platform. This questionnaire and every experimental task were password protected; only participants in participating courses had access to the password. After completing the questionnaire, participants read the consent form and clicked a box indicating they had read and accepted the form before continuing. Clearly written instructions on how to complete the tasks, and how to navigate the FindingFive platform,
appeared on the participants’ computer screen. Participants completed the Verbal Fluency Task first. After completing the Verbal Fluency Task, the participants had a short break, then completed the English LDT, Spanish LDT, and Translation Recognition Task. Small two-minute breaks were included between each task. A short break was also included between the two blocks of the Translation Recognition Task. After completing the tasks, participants were notified of the second experimental session scheduled for four weeks after completing the first session. Participants followed the same procedure for the second session, completing the same experimental tasks in the same order as session one.

**Analysis**

Verbal fluency performance was calculated by averaging the number of exemplars produced across categories. ANOVAs were performed with group as a between subject variable to measure any significant differences between English verbal fluency. Initial descriptive analyses on the three experimental tasks were carried out using separate ANOVAs with session as a within subjects variable and group as a between subjects variable.

All other statistical analyses were carried out using linear mixed-effects models in the lme4 software package (Bates et al. 2014) in R (version 1.3.1073). For RT and accuracy in the English LDT, the analysis included fixed effects of session, group, L2 known and their interaction. L2 known was a categorical variable indicating whether the L2 translation equivalent of the English stimulus word was responded to correctly in the Spanish LDT across both sessions (previously known), only in session two (learned), or in neither session (unknown). For RT in the Spanish LDT, the analysis included fixed effects of session, group, and their interaction. To decrease the likelihood of Type-1 errors, random effects were structured following the maximal LMER procedure laid out
by Barr et al. (2013). This process resulted in several implausible random effects (lack of convergence and/or correlations of 1), suggesting models were degenerate. Thus, these implausible effects were removed, and models were fit to simplified random effects structures. The final model for both lexical decision tasks had random effects including by-participant varying intercepts and by-item varying intercepts.

For RT and accuracy in the translation recognition task, the analysis included a fixed effect of group, type, relatedness, session, and their interactions. The random effect structure included by-participant varying intercepts and by-item varying intercepts. By-item varying condition slopes and by-participant varying condition slopes were removed due to lack of convergence and/or singularity.

D prime (d’) analyses were also carried out on both lexical decision tasks using the psycho package (Makowski 2018) in the R program.
Chapter 4

Results

**Verbal Fluency Task (English).** Total mean exemplars produced across each session was similar across all three groups (see Table 2). The less proficient group produced slightly fewer English exemplars (mean = 13.8, SD = 4.9) as compared to the more proficient group (mean = 14.4, SD = 4.7) and the control group (mean = 14.2, SD = 4.2). A 2 (session: session one vs. session two) * 3 (group: more proficient vs. less proficient vs. control) ANOVA with mean exemplars produced as the dependent variable revealed no significant effects of group [$f(2, 14) = 0.1, p = 0.8$] or session [$f(1, 14) = 0.03, p = 0.95$]. However, a mixed model revealed that the less proficient group produced significantly less exemplars in session two as compared to session one ($\beta = -2.7$, $SE = 1.3$, $df = 175$, $t = -2.0$, $p < 0.05$).

**Table 2 - Mean (and SD) exemplars produced in English across categories.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1 Mean Exemplars Produced</th>
<th>Session 2 Mean Exemplars Produced</th>
<th>Average Totals Mean Exemplars Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Proficient</td>
<td>15.1 (4.4)</td>
<td>12.7 (5.1)</td>
<td>13.8 (4.9)</td>
</tr>
<tr>
<td>More Proficient</td>
<td>15.0 (3.4)</td>
<td>13.7 (5.9)</td>
<td>14.4 (4.7)</td>
</tr>
<tr>
<td>Control</td>
<td>13.8 (4.6)</td>
<td>14.7 (3.9)</td>
<td>14.2 (4.2)</td>
</tr>
</tbody>
</table>

**Verbal Fluency Task (Spanish).** As mentioned in the participants section, participants in the study were split into two categories: less proficient and more proficient
L2 learners. A 2 (group: less proficient vs. more proficient) * 2 (session: session 1 vs. session 2) ANOVA with mean exemplars produced as the dependent variable revealed a significant difference of group \[ f(1, 13) = 40, p < 0.05 \] and no significant difference of session \[ f(1, 13) = 0.01, p = 0.9 \]. Further analysis using a mixed model confirmed that the more proficient group produced more Spanish exemplars on average than the less proficient group (\( \beta = 3, SE = 0.4, df = 140, t = 4.6, p < 0.05 \)). Table 3 below illustrates these significant differences.

**Table 3 - Mean (and SD) exemplars produced in Spanish across categories.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1 Mean Exemplars Produced</th>
<th>Session 2 Mean Exemplars Produced</th>
<th>Average Totals Mean Exemplars Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Proficient</td>
<td>3.9 (2.5)</td>
<td>4.5 (3.0)</td>
<td>4.2 (2.8)</td>
</tr>
<tr>
<td>More Proficient</td>
<td>7.4 (3.1)</td>
<td>6.7 (3.1)</td>
<td>7.1 (3.1)</td>
</tr>
</tbody>
</table>

*Increases in L2 proficiency.*

**Spanish Lexical Decision Task.** A 2 (group: less proficient vs. more proficient) * 2 (session: session 1 vs. session 2) ANOVA using accuracy as the dependent variable revealed a significant effect of group \[ f(1, 20) = 5.4, p < 0.05 \]. As shown in
Table 4, more proficient participants made decisions about Spanish words far more accurately (95.1%) compared to the less proficient participants (85.2%).

Table 4.

Mean Accuracy and Reaction Times (ms) and SD for the Spanish LDT

<table>
<thead>
<tr>
<th>Group</th>
<th>Session 1</th>
<th></th>
<th>Session 2</th>
<th></th>
<th>Average Totals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT (ms)</td>
<td>% Acc</td>
<td>RT</td>
<td>Acc</td>
<td>RT</td>
<td>Acc</td>
</tr>
<tr>
<td>Less Proficient</td>
<td>999(361)</td>
<td>84.4(2.1)</td>
<td>962(345)</td>
<td>86.4(1.3)</td>
<td>981(354)</td>
<td>85.2(3.5)</td>
</tr>
<tr>
<td>More Proficient</td>
<td>938(346)</td>
<td>95.5(2.1)</td>
<td>867(297)</td>
<td>96.5(1.8)</td>
<td>902(323)</td>
<td>95.1(1.8)</td>
</tr>
</tbody>
</table>

Linear mixed-effects models of reaction time revealed that both groups responded significantly faster across sessions. As shown in

Table 5 both the less proficient group and more proficient group ($\beta = -57, SE = 23, df = 1248, t = -2.7, p < 0.05$) correctly identified Spanish words faster in the second session as compared to the first. An additional mixed model on accuracy (see Table 6) revealed that the more proficient group was significantly more accurate than the less proficient group ($\beta = 0.12, SE = 0.04, df = 25, t = 2.8, p < 0.05$). These results indicate that both groups increased knowledge of Spanish words over the course of the testing period.
Repetition Effects

To account for any possible repetition effects across sessions, Spanish non-word RTs were compared to Spanish word RTs. A mixed model built for the Spanish non-words revealed no significant increase in RT across sessions ($\beta = -32, SE = 27, df = 1216$, $t = -1.1, p = 0.2$). This result shows that the repetition of words and non-words across sessions did not similarly increase, indicating that the increase in RT to Spanish words can be related more so to increases in L2 knowledge rather than repetition effects.

Table 5.

Estimated Coefficients from the Spanish LDT Mixed Model on RT(ms)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate(ms)</th>
<th>SE</th>
<th>df</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>1026</td>
<td>45</td>
<td>26</td>
<td>22</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Session</td>
<td>-57</td>
<td>21</td>
<td>1248</td>
<td>-2.7</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>More Proficient</td>
<td>-73</td>
<td>78</td>
<td>22</td>
<td>-0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Session: More Proficient</td>
<td>-21</td>
<td>34</td>
<td>1247</td>
<td>-0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>Item</td>
</tr>
<tr>
<td>Intercept</td>
<td>Participant</td>
</tr>
</tbody>
</table>

Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session 1/less proficient was set as the reference level.

Table 6.
Estimated Coefficients from the Spanish LDT Mixed Model on Accuracy

**Random Effects**

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.02</td>
<td>0.12</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.006</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session 1/ less proficient was set as the reference level.

L2 meaning access.

**Translation Recognition Task.**

**Reaction Time**

Across both sessions, results for the less proficient group (see Table 7) showed that participants took longer to reject semantic distractors (1007ms) than the controls (947ms). Across sessions, semantic interference decreased by 49ms for less proficient participants. Similar results were found for the translation condition; overall across sessions, results showed that it took longer to reject the translation distractors (979ms) than controls (922ms). Across sessions, translation-form interference increased by 45ms across sessions.

Across both sessions for more proficient participants (see Table 8), results showed that it took longer to reject the semantic distractors (1006ms) than the controls (898ms). Translation-form pairs were also rejected slower (985ms) than the controls (926ms). Across sessions, translation-form interference decreased by 37ms.
**Accuracy**

Less proficient participants responded less accurately to the semantic distractors (81%) than the control words (92%). Translation distractors were also responded to less accurately (88%) than the control words (93%).

More proficient participants responded slightly less accurately to the semantic distractors (90%) than the control words (95%). Translation distractors were also responded to less accurately (97%) than the control words (99%).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Overall Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Acc</td>
<td>RT</td>
</tr>
<tr>
<td>Semantic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>1043(401)</td>
<td>80.1(3.9)</td>
<td>971(382)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>958(366)</td>
<td>93.3(1.6)</td>
<td>935(394)</td>
</tr>
<tr>
<td><strong>Interference</strong></td>
<td><strong>85</strong></td>
<td></td>
<td><strong>36</strong></td>
</tr>
<tr>
<td>Translation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>995(370)</td>
<td>88.3(1.3)</td>
<td>963(369)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>960(369)</td>
<td>95.1(1.8)</td>
<td>883(363)</td>
</tr>
<tr>
<td><strong>Interference</strong></td>
<td><strong>35</strong></td>
<td></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>
Table 8 – Mean RTs, Accuracy and SDs for the TRT (More proficient)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Session 1</th>
<th></th>
<th>Session 2</th>
<th></th>
<th>Overall Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT (Acc)</td>
<td>RT (Acc)</td>
<td>RT (Acc)</td>
<td></td>
<td>RT (Acc)</td>
</tr>
<tr>
<td>Semantic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>1033(399) 87.9(2.1)</td>
<td>983(364) 92.2(1.3)</td>
<td>1006(381) 90.1(0.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>970(343) 99.1(1.3)</td>
<td>831(282) 1</td>
<td>898(321) 99.5(1.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interference</td>
<td>63</td>
<td></td>
<td>152</td>
<td></td>
<td>108</td>
</tr>
<tr>
<td>Translation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>1063(368) 96.3(2.2)</td>
<td>913(993) 98.2(1.3)</td>
<td>985(328) 97.3(1.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>985(361) 99.1(2.2)</td>
<td>872(300) 99.1(2.1)</td>
<td>926(359) 99.1(2.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interference</td>
<td>78</td>
<td></td>
<td>41</td>
<td></td>
<td>59</td>
</tr>
</tbody>
</table>

RT Mixed Models

To further analyze RT, two separate mixed models were built based on Type of Interference/Distractor (Semantic vs. Form).

Table 9 contains the estimated coefficients for the Form type while Table 10 contains the estimated coefficients for the Semantic type.

For both participant groups, significant form-related interference was not detected ($\beta = 28, SE = 27, df = 299, t = 1, p =0.2$). However, there was a significant effect of session ($\beta = -71, SE = 23, df = 2526, t = -3, p < 0.05$), indicating that all participants
responded to both translation-form related and unrelated words faster in session two. All other effects and interactions were not significant.

In the Semantic model (Table 10), we see several significant effects. First, semantic interference was significant for both groups (β = 111, SE = 27, df = 328, t = 3.9, p < 0.05). Next, the more proficient group responded significantly faster to all word-pair combinations in the second session (β = -106, SE = 41, df = 2465, t = -2.5, p < 0.05). Lastly, semantic interference was more pronounced for the more proficient group in the second session (β = 149, SE = 59, df = 2469, t = 2.4, p < 0.05).

Put together, the results from both models show that, during comprehension, participants were sensitive to semantically related words but not to form related words. Semantic interference in both groups suggests that the L2 learners were accessing meaning directly during comprehension. Additionally, the more proficient participants were particularly sensitive to semantically related words in session two, even despite their overall increase in RT to all word-pairs across sessions. This indicates that the more proficient group developed stronger access to meaning throughout the experimental period. The reason for the lack of form interference is not entirely clear.
Table 9.

*Estimated Coefficients from the TRT Mixed Model on RT (ms). Form-Model*

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate (ms)</th>
<th>SE</th>
<th>df</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>978</td>
<td>33</td>
<td>38</td>
<td>29</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>More Proficient</td>
<td>22</td>
<td>55</td>
<td>31</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Related</td>
<td>28</td>
<td>27</td>
<td>299</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Session</td>
<td>-71</td>
<td>23</td>
<td>2526</td>
<td>-3</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>More Proficient: Related</td>
<td>16</td>
<td>40</td>
<td>2505</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>More Proficient: Session</td>
<td>-49</td>
<td>39</td>
<td>2506</td>
<td>-1.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Related: Session</td>
<td>11</td>
<td>33</td>
<td>2535</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>More Proficient: Related:Session</td>
<td>-29</td>
<td>56</td>
<td>2512</td>
<td>-0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>Item</td>
<td>3676</td>
</tr>
<tr>
<td>Intercept</td>
<td>Participant</td>
<td>10527</td>
</tr>
</tbody>
</table>

*Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session 1/Less Proficient/Unrelated was set as the reference level.*

Table 10.

*Estimated Coefficients from the TRT Mixed Model on RT (ms). Semantic-Model*

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate (ms)</th>
<th>SE</th>
<th>df</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>983</td>
<td>33</td>
<td>38</td>
<td>28</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>
More Proficient  -2  56  34  -0.05  0.9
Related  111  27  328  3.9  < 0.05
Session  -36  24  2467  -1.4  0.1
More Proficient: Related  -33  42  2475  -0.7  0.4
More Proficient: Session  -106  41  2465  -2.5  < 0.05
Related: Session  -59  35  2481  -1.6  0.09
More Proficient:  149  59  2469  2.4  < 0.05
Related: Session

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>Item 1149</td>
<td>33</td>
</tr>
<tr>
<td>Intercept</td>
<td>Participant 7776</td>
<td>88</td>
</tr>
</tbody>
</table>

Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session 1/Less Proficient/Unrelated was set as the reference level.

L2-on-L1 effects.

**English Lexical Decision Task.** As shown in Table 11, all three groups displayed high levels of accuracy in the task. A 2 (session: session 1 vs. session 2) x 3 (group: less vs. more vs. control) ANOVA with accuracy as the dependent variable revealed no significant group [$f(2, 21) < 0.01, p = 0.7$] or session [$f(1,21) < 0.01, p = 0.4$] differences.

With RT as the dependent variable, there were no significant group [$f(2, 21) = 0.54, p = 0.5$] or session [$f(1, 21) = 1.6, p = 0.2$] differences.

**Table 11.**

*Mean Accuracy and Reaction Times (ms) and SD for the English Lexical Decision Task*
<table>
<thead>
<tr>
<th>Group</th>
<th>RT</th>
<th>Acc</th>
<th>RT</th>
<th>Acc</th>
<th>RT</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proficient</td>
<td>769(322)</td>
<td>97.2(1.5)</td>
<td>791(379)</td>
<td>97.3(1.5)</td>
<td>780(350)</td>
<td>97.2(1.5)</td>
</tr>
<tr>
<td>More</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proficient</td>
<td>874(342)</td>
<td>96.3(1.8)</td>
<td>829(320)</td>
<td>98.1(1.8)</td>
<td>842(325)</td>
<td>97.1(1.7)</td>
</tr>
<tr>
<td>Control</td>
<td>933(334)</td>
<td>95.2(1.2)</td>
<td>807(263)</td>
<td>96.2(1.6)</td>
<td>869(306)</td>
<td>95.5(1.4)</td>
</tr>
</tbody>
</table>

*Effect of L2 known words on L1 retrieval.*

As mentioned in the data analysis section, the L2 known fixed effect was a categorical variable consisting of 3 types of words: *unknown, learned, and known previously*. Mixed model analysis revealed no significant effect of L2-known on RT for either proficiency group (see
Table 13). Accuracy was very similar across sessions for both learned words and words known previously. However, it is interesting to note that while accuracy across categories was uniformly high in session one (see

Table 12), unknown words were retrieved far less accurately in session two (88%, SD = 3%) than session one (100%, SD = 0%). A L2 known * Session interaction (see

Table 14) revealed that this small decrease in accuracy was significant ($\beta = -1.491e-01$, $SE = 3.658e-02$, $df = 1.655e+03$, $t = -4$, $p < 0.05$). These results suggest that words unknown in the L2 may be most affected by introduction of new words from a different language into lexicon.

Table 12 – Effect of L2 Word Knowledge on L1 Word Retrieval (Less Proficient)

<table>
<thead>
<tr>
<th>Word</th>
<th>Session 1</th>
<th></th>
<th>Session 2</th>
<th></th>
<th>Average Totals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Acc</td>
<td>RT</td>
<td>Acc</td>
<td>RT</td>
<td>Acc</td>
</tr>
<tr>
<td>Unknown</td>
<td>600(119)</td>
<td>1(0)</td>
<td>756(123)</td>
<td>0.88(0.03)</td>
<td>678(135)</td>
<td>0.94(0.03)</td>
</tr>
<tr>
<td>Learned</td>
<td>798(340)</td>
<td>0.97(0.03)</td>
<td>772(325)</td>
<td>0.97(0.03)</td>
<td>785(316)</td>
<td>0.97(0.03)</td>
</tr>
<tr>
<td>Known Previously</td>
<td>785(344)</td>
<td>0.97(0.03)</td>
<td>807(336)</td>
<td>0.97(0.03)</td>
<td>796(342)</td>
<td>0.97(0.03)</td>
</tr>
</tbody>
</table>
Table 13.

*Estimated Coefficients from the English LDT Mixed Model on RT*

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate</th>
<th>SE</th>
<th>df</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>873</td>
<td>89</td>
<td>27</td>
<td>9.7</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Less Proficient</td>
<td>-88</td>
<td>100</td>
<td>26</td>
<td>-0.8</td>
<td>0.3</td>
</tr>
<tr>
<td>More Proficient</td>
<td>13</td>
<td>110</td>
<td>26</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Learned Words</td>
<td>29</td>
<td>38</td>
<td>1669</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Unknown Words</td>
<td>-126</td>
<td>82</td>
<td>1654</td>
<td>-1.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Session</td>
<td><strong>-139</strong></td>
<td>40</td>
<td>1652</td>
<td>-3.4</td>
<td><strong>&lt; 0.05</strong></td>
</tr>
<tr>
<td>Less Proficient: Session</td>
<td><strong>167</strong></td>
<td>45</td>
<td>1650</td>
<td>3.6</td>
<td><strong>&lt; 0.05</strong></td>
</tr>
<tr>
<td>More Proficient: Session</td>
<td>89</td>
<td>48</td>
<td>1648</td>
<td>1.8</td>
<td>0.06</td>
</tr>
</tbody>
</table>
## Table 14.

Estimated Coefficients from the English LDT Mixed Model on Accuracy

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Estimate (ms)</th>
<th>SE</th>
<th>df</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>9.785e-01</td>
<td>2.141e-02</td>
<td>4.737e+01</td>
<td>45</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Less Proficient</td>
<td>-4.785e-03</td>
<td>9.328e-03</td>
<td>1.655e+03</td>
<td>-0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>More Proficient</td>
<td>-1.104e-02</td>
<td>1.010e-02</td>
<td>1.655e+03</td>
<td>-1</td>
<td>0.2</td>
</tr>
<tr>
<td>Learned Words</td>
<td>-5.165e-03</td>
<td>1.212e-02</td>
<td>1.657e+03</td>
<td>-0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Unknown Words</td>
<td>5.357e-02</td>
<td>2.628e-02</td>
<td>1.657e+03</td>
<td>2</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Session</td>
<td>-7.072e-03</td>
<td>1.219e-02</td>
<td>1.655e+03</td>
<td>-0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Less Proficient:</td>
<td>1.327e-02</td>
<td>1.398e-02</td>
<td>1.655e+03</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>More Proficient:</td>
<td>2.776e-02</td>
<td>1.495e-02</td>
<td>1.655e+03</td>
<td>1.8</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>L2known</td>
<td>7006</td>
</tr>
<tr>
<td>Intercept</td>
<td>Participant</td>
<td>28555</td>
</tr>
</tbody>
</table>

Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session one/control group/words known previously was set as the reference level.
Further analyses using $D'$

While no explicit L2-on-L1 effects were found, further analyses using $d'$ uncovered intriguing sensitivity differences between participant groups. As shown in Figure 4, the less proficient group was less sensitive to words in the Spanish LDT as compared to the more proficient group. This difference was expected due to the varying proficiency levels of the two groups. Across sessions, both the less proficient and more proficient groups increased in sensitivity. Paired t-tests revealed that mean $d'$ across sessions were significantly different for the less proficient group, $t(13) = 1.8, p < 0.05$, but not for the more proficient group, $t(6) = 1.7, p = 0.06$. These results were expected; less proficient learners were predicted to be less sensitive to Spanish words than the more proficient group and significant increases in sensitivity were predicted to be more likely for the less proficient group.

| Learned Words: | -5.717e-03 | 1.654e-02 | 1.655e+03 | -0.3 | 0.7 |
| Unknown Words: | -1.491e-01 | 3.658e-02 | 1.655e+03 | -4 | < 0.05 |

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>L2known</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Note: Bold indicates that the coefficients are significantly different from the reference level (0). Session one/control group/words known previously was set as the reference level.
When comparing Spanish LDT sensitivity to the English LDT sensitivity, we see some intriguing differences between groups. As shown in Figure 5, the less proficient group was less sensitive in session one, but this sensitivity increased in session two. A paired t-test indicated that these means were significantly different, \( t(13) = 1.8, p < 0.05 \). The more proficient group had the highest overall sensitivity. No significant difference was found across sessions, \( t(6) = 1.1, p = 0.14 \). The control group was too small to evaluate for changes in d’ but their sensitivity was within the range of the two experimental groups. Most intriguing of these results is the parallel increase in sensitivity shown by the less proficient group in both the Spanish LDT and English LDT. The more proficient group displayed a similar increase in sensitivity across sessions in the Spanish LDT, but this change was not similarly reflected in the English task like it was for the less proficient group. Of course, these parallels are in no way explicit L2-on-L1 effects, but
they do suggest that the introduction of a second language may affect sensitivity during comprehension in the first language.

**Figure 5 - English LDT Cross Session d' Scores**

Chapter 5

Discussion

The present study investigated two central topics: language co-activation in the form of facilitated L1 word retrieval, and how L2 learners access the meanings of words. Two groups of L2 learners of Spanish completed three behavioral tasks across two sessions. The first of these tasks, the English Lexical Decision Task, aimed to measure co-activation; its goal was to measure any facilitation in the retrieval of L1 words for
which the L2 translation equivalent was known or learned across sessions. The second task, the Spanish Lexical Decision Task, aimed to track developmental changes in L2 learning, and provide a measure of which English words participants had learned in Spanish, or L2-known status – words previously known in Spanish, learned across sessions, or unknown words. The last task, the Translation Recognition Task, aimed to measure the extent to which the learners could access L2 meaning directly and/or if they relied on L1 mediation to access meaning during comprehension. Like the results section, discussion will begin with the Spanish LDT, followed by the TRT, then by the English LDT and d’ analyses. The current study’s limitations and future research will also be discussed.

**Spanish Lexical Decision Task.**

*L2 developmental increases*

Both experimental groups displayed significantly faster response times to the Spanish target words across sessions. By contrast, minor increases in accuracy were not significantly different from Session 1 to Session 2. As predicted, participants in the more proficient group were faster and more accurate in recognizing Spanish words than the less proficient participants. Further analyses on RT revealed that these increases in RT were unique to Spanish words; non-words did not undergo a similar increase in retrieval speed. This illustrates that the significant increase in response times to Spanish words can be more closely associated with L2 learning rather than repetition effects. Given the unusual public health context during which the study was completed, these results provide reassurance that changes in learning can be reliably detected in university students engaged in online classes, using online experimental interventions. Learning an L2 and
successfully increasing in proficiency is challenging at the post-secondary level (Lusin 2012). Online and hybrid courses are often thought to substantially increase this difficulty. While this may be the case for certain individuals, broad institutional surveys (Means et al. 2009) have found that online learning offered a modest advantage over traditional face-to-face courses, but this advantage was modulated by time spent on certain L2 learning tasks. The factor of time spent with learning materials is an important factor related to the online modality; students in online courses often spend more time with L2 materials which results in increases in proficiency (Barr 2013). While the COVID19 pandemic has resulted in an unexpected shift to these online learning contexts, we can say with some positivity that the current study does support the general claims that L2 learning is possible in this context. While it remains unclear the exact factors behind such proficiency developments, or if such developments would have occurred with the same sample in a face-to-face context, we can conclude that, over the course of the testing period, participants became more sensitive to L2 words.

In direct relation to the online learning context is the similarly online experimental context. Due to the current circumstances presented by COVID19, researchers worldwide have quickly adapted to online experimental methodologies, and while running experiments online presents its own difficulties, the Spanish LDT results illustrate that this modality does not completely restrict the possibility of observing significant effects. Both the less proficient and more proficient groups showed significant decreases in RT to Spanish words over both sessions, indicating that online experimentation can capture developmental changes. Capturing these developmental changes was a central part of the current study, and while not all predicted results were found, we can conclude that measuring L2 development is possible, even in an online setting. This presents hope for future research on L2 learners using similar longitudinal methods; it has been shown here
that even less proficient learners are becoming more sensitive to L2 words in a short period of time. With more precise measurements, future studies can aim to relate such changes to any subtle co-activation and cognitive changes that may occur in parallel.

Translation Recognition Task.

L2 Meaning Access

The TRT revealed intriguing results from both participant groups. Interestingly, the less proficient participants displayed significantly increased RTs to semantic distractors, even in the first session. This indicates that L2 meaning access was possible very early during development, which is consistent with results from Ma et al. (2017). These results may also suggest that the less proficient participants had prior Spanish exposure and/or learning experiences. No evidence was found for translation-form interference.

The more proficient participants rejected semantic distractors more slowly and less accurately than control words. Following predictions, this interference was present in session one and continued through session two. Mixed model analyses also showed that semantic interference became more prominent in session two. No evidence was found for translation-form interference. These results align with predictions made by the RHM; as proficiency increases, reliance on L1 mediation decreases. However, the lack of evidence for translation-form interference is at odds with several past studies, which have reported higher translation interference with L2 learners (Ferré et al. 2006; Talamas et al. 1999).

Some, but not all the results from each group align with the behavioral results found from Sunderman & Kroll (2006) and Ma et al. (2017). Like the Sunderman & Kroll (2006) study, participants in the current study also displayed significant semantic
interference, indicating that even these learners are sensitive to meaning during L2 processing. However, translation-form interference was not detected, which is contrary to findings from Sunderman & Kroll (2006) and Ma et al. (2017). These studies showed both translation-form and semantic interference during comprehension.

ERP results from Ma et al. (2017) indicate that learners can access the meaning of an L2 word directly in comprehension, without the help of the translation equivalent. Specifically, Ma et al. found that learners experience semantic interference even at a short SOA (250ms), indicating that meaning access can occur prior to and apart from L1 mediation. Unlike the Ma et al. study, the current study did not utilize separate SOAs during testing. The current study employed a very long SOA (1000ms). Ma et al. showed that both semantic and translation interference were detected at their long SOA (750ms). The results for the current study did not align with Ma et al.’s findings; participants experienced only semantic interference at a long SOA, when translation-form interference was also predicted. Further analyses showed that not all participants in the less proficient group displayed this semantic interference, indicating that direct access to meaning from L2 words may not be uniform across early L2 learners. Put differently, while the less proficient learners were given quite a long time (1000ms) between the control and distractor, this did not completely influence every participant, indicating that some learners may have accessed L2 meaning directly, while others did not. However, without comparison to a short SOA, we hesitate to say that L2 meaning access occurred without L1 mediation.

It remains unclear why both groups of participants were not significantly affected by the translation-form distractors. One possible explanation could be the linguistic environment in which the participants live. As mentioned in the method section, many of participants reported some degree of exposure to Spanish words throughout their lifetime.
This exposure may have indirectly strengthened L2 meaning access and weakened reliance on L1 translation equivalents. Further studies comparing L2 learners of similar proficiencies from different linguistic environments may shed more light on the influence of L2 exposure during developmental comprehension.

While each proficiency group displayed somewhat unexpected results in comparison to one another, we can say that each group displayed semantic inference, thus indicating L2 meaning access. This finding does align with Sunderman & Kroll (2006) and Ma et al. (2017). Additionally, we can state related yet unique findings: L2 meaning access was achieved by participants who learned the L2 in an online context and took the experiment in an online context. The fact that our findings on direct L2 meaning access aligned with these past studies is exciting given these external variables. Furthermore, due to the current study’s longitudinal design, we were able to document increases in L2 meaning access in parallel with L2 developmental increases.

Lastly, it is important to note that the robustness of the semantic effects found in the translation recognition task could arguably be related to the task itself because participants’ attention is directed to meaning relationships between words. If the manipulation between semantic word pairs was stronger than that between translation-form word pairs, this could explain the lesser degree of interference from the latter condition. And, as mentioned by Ma et al. (2017), access to meaning is an integral part of a translation recognition task, and this could augment the amount of interference seen within both conditions. It remains to be seen if similar patterns of meaning access would be found in tasks in which participants are not instructed to evaluate the semantics of the stimuli.
English Lexical Decision Task.

L2-on-L1 effects

Contrary to predictions, words previously known or learned during L2 development did not significantly influence retrieval of these words in the L1. These results are contrary to the study done by Higby et al. (2019), who found that L2-known words facilitated L1 word retrieval (in picture naming). There are several important distinctions between the current study and that of Higby et al. which may help explain these contradictory results.

First, Higby et al.’s participants were immersed in an L2 context outside of testing while the participants in the current study were not. This immersion context may explain why an effect of L2-known was more significant in the Higby et al. study; L2 immersion would reduce overall activation levels of L1 words, resulting in more susceptibility to boosts in activation received from known L2 words. Because participants in the current study were learning an L2 in an L1 context, it may be the case that their L1 words were at higher levels of activation, thus making indirect frequency boosts from L2 known words less likely. However, while evidence of active L1 suppression in L2 immersion contexts have been found (Linck, Sunderman & Kroll 2009), it is unclear if suppression actively influences the effect of L2 known words on L1 retrieval.

Second, Higby et al.’s study tested facilitative access during production while the current study aimed to measure facilitative access during comprehension. Several past studies have demonstrated that translation equivalents facilitate word retrieval in language production in both children and adults (Costa et al. 2000, Gollan et al. 2004, Poarch & Van Hell 2013, Dylman & Barry 2018). Facilitation during language comprehension has also been found, most clearly for cognates (Poort & Rodd 2017; Dijkstra et al. 2010).
However, less evidence has been found for similar facilitative effects during comprehension in less proficient adult language learners (Bice & Kroll 2015). Notably, Bice and Kroll found that during lexical decision in the L1, intermediate L2 learners demonstrated a reduced N400 for cognates as compared to non cognates, and an emerging effect was visually present for beginning learners. Furthermore, no behavioral cognate effect was present for either group, indicating facilitative interactions during comprehension may be very subtle and hard to detect with behavioral measures. Put together, cross-language facilitation during both comprehension and production also appears heavily influenced by cognates. However, as argued by Higby et al., who found no significant interaction between L2-known words and cognate status during L1 production, the facilitative effect of parallel co-activation should in theory exist for all translation equivalents. The current study tested this claim by including no cognates in the three behavioral tasks and found no evidence for the facilitative effect of parallel co-activation during *comprehension*. It may be the case that these effects are easier to detect during language production, especially for L2 learners immersed in an L2 context.

While L1 retrieval in the current study was not influenced by L2-known words, this does not mean there were not cross-language interactions occurring. It may be the case that, in the current study, subtle effects like those found in the Bice & Kroll study were present, albeit undetectable by online behavioral measures. Contrarily, it may also be the case that these L2-on-L1 effects were not present at all. However, the absence of no interaction whatsoever is challenged by additional sensitivity results using d’.

*Sensitivity with d’*

Analyses on sensitivity provided some evidence of changing performance on the English LDT despite the absence of significant L2-on-L1 effects. Stemming from signal
detection theory, d’ gives a by-participant measure of sensitivity to signals. In a task like
the lexical decision task, participants are asked to detect signals in the form of words and
non-words, by responding *yes, this is a word* or *no, this is a non-word*. Using how
participants responded to these signals (and non-signals), we can model their sensitivity
using d’.

In the current study, accuracy (or % correct) and reaction time (RT) were the
central dependent variables used when measuring possible co-activation. Unfortunately,
these measures did not reveal any significant facilitation effects. While these null results
are disappointing, by-participant d’ scores give the opportunity to examine changes in
sensitivity across participant groups and provide a new perspective into cross-language
interaction. Before discussing the d’ scores, it is important to note that these scores are
not in any way explicit evidence of L2-on-L1 effects. Rather, these scores can tell us how
participants’ sensitivity changed across sessions in both the English and Spanish tasks.

As shown in the results section in Figure 4 and Figure 5, sensitivity during the
English LDT was not uniform across groups. The less proficient group showed low
sensitivity in session one and higher sensitivity in session two. The more proficient group
showed higher than average sensitivity in session one and decreased sensitivity in session
two. The control group showed similar sensitivity across both sessions. These differences,
when compared by themselves, do not tell us anything specific to the items included in
the tasks; only that the groups showed varying levels of sensitivity during the English
LDT. However, when we compare these changes in sensitivities to those found in the
Spanish LDT, we find something interesting. In the Spanish LDT, the less proficient
groups displayed very low sensitivity to Spanish words in session one. This is
understandable due to their lower proficiency. At session two, sensitivity *increased*,
which shows that participants were more careful the second time around, indicating
possible correlations with proficiency increases. The more proficient group also displayed increases in sensitivity across sessions. Now, if we turn back to the English LDT, we see that the less proficient learners show a similar increase in sessions that they showed in the Spanish LDT. More proficient learners do not show this parallel increase. If these sensitivity changes were driven only by task repetition and familiarity, then we would see the control group display some sort of change in sensitivity. However, such a change is not present, indicating that there may be an interaction between the sensitivity of L2 words and their L1 translation equivalents.

This possible interaction is worth consideration under the Lexical Quality Theoretical Framework (Perfetti & Hart 2002). Within this framework, readers identify words rather than recognizing them, implying that words have identities. Perfetti (2017) explains that the identity of a word is given by a simple triplet formulation: orthographic form, phonological form, and core meanings. The knowledge of each of these constituents and the words that they define are unique across individuals, and some individuals have higher quality word representations than others. This is due to the variance in lexical quality - defined as the degree to which word identification involves the seamless and synchronous activation of the three constituents mentioned above (Perfetti 2017). Now, how does this relate to the d’ interaction mentioned above? First, we can say that, following assumptions made by the LQ framework, word identities for bilinguals and L2 learners would theoretically have form constituents from both languages. More importantly, however, is that words known in both languages would have shared core meanings and shared (or possibly varied) contexts of use. Put simply, learning an L2 word could in theory change the “identity” of the L1 translation equivalent, thus making identification of that L1 word influenced by the constituents of the L2 translation equivalent. Now, if we look back to the less proficient groups’ d’
scores, we see a significant change in sensitivity to both L1 and L2 words across sessions. The constituents of the L1 words do not change across sessions. What does change, however, are the total amount of constituents influential to the identification of L1 words; upon learning the L2 translation equivalent of L1 words, the linguistic form and meaning properties of these L2 words may now be influential during L1 identification. Following these assumptions, we can theorize that this increase in sensitivity to L1 words may have been influenced by the constituents of learned L2 translation equivalents. Of course, the extent to which this $d'$ interaction is related to the addition of constituents is reliant on the proposition that $d'$ scores can be representative of lexical quality. While is it not clear if this is indeed the case, the LQ framework gives us one way to interpret the changes in sensitivity we see in the less proficient learners.

Limitations and Future Studies

Limitations to the current study and possible future studies will be discussed below. The current study failed in revealing explicit L2-on-L1 effects. There are several possible reasons why these effects were not found. As mentioned in previous sections, the current study focused on the comprehension of noncognate translation equivalents. Evidence of facilitatory effects for noncognate words are known to be more difficult to find as compared to cognates. The choice not to include cognates in the current study may have deprived us of effects that have been shown to be stronger, especially for less proficient groups (Bice & Kroll 2015). In addition to the exclusion of cognates, the study’s focus on language comprehension may have also resulted in further difficulties. While facilitative effects due to parallel co-activation during comprehension have been found in more proficient bilinguals (Poort & Rodd 2017; Dijkstra et al. 2010), behavioral effects are difficult to detect in less proficient learners (Bice & Kroll 2015). Language production appears to exhibit more facilitative effects in behavioral studies (Costa et al.
While L2-on-L1 effects during comprehension appear more subtle in less proficient learners, this does not render it any less intriguing. Future research on less proficient learners could investigate the degree to which learners experience facilitative and/or inhibitory effects in both language production and comprehension, while simultaneously tracking L2 development, and comparing the relative amounts of co-activation that occur across both domains of language use. Doing so could reveal more about the underlying factors influencing co-activation in this understudied population. Furthermore, by comparing data from both language production and comprehension measures in the same L2 learner population, we would be able to better track the degree to which co-activation occurs in parallel with certain stages of L2 development. Future studies into less proficient L2 learners would also greatly benefit from recorded event-related brain potentials (ERPs), which have been used to measure brain responses to sensory, cognitive, or motor experiences.

Next, the main predictor thought to influence L2-on-L1 effects, L2-known, was not influential in the study. In hindsight, this variable could have been coded differently to better reflect L2 word knowledge. Using a lexical decision task to measure word knowledge was not the best choice; labeling a word as known or learned only because it was recognized does not necessarily mean the word was known. There are certainly better ways to determine L2 word knowledge, including tasks like the L2 vocabulary test used by Higby et al. (2019). In their study, Higby et al. used results from an L2 vocabulary test for each participant to compare L1 picture naming speed for pictures that participants could name only in the L1 with those the participant knew in both languages. In this way, Higby et al. were able to achieve a more nuanced look at how co-activation affects word retrieval. The ability to individualize L2 vocabulary knowledge in relation to the word
retrieval measure gave this variable far greater predictive strength. Unfortunately, these individual measures were not present in the current study. Utilizing the Spanish LDT as the measure for L2-known was the most accessible given the structural and temporal pressures which were part of the current study. However, future longitudinal studies of this similar nature would greatly benefit from similar individual measures to those used by Higby et al. (2019). By individualizing L2 vocabulary knowledge, proficiency increases could be easily tracked by-participant across sessions, resulting in a variable more representative of individual proficiency changes over time. Changes in L2 proficiency could then be individualized in parallel alongside any changes in L1 word retrieval.

Next, the study’s design, online format, and small sample size resulted in data that was non-normally distributed and difficult to interpret. After data cleaning, standard deviations were very high, especially for reaction time. The study, which was completed online, took between 45 minutes to 1 hour to complete. Due to the online context and longer length of study, participants were more likely to be distracted during participation. While several breaks were added to decrease fatigue and increase attention, overall attention could not be monitored due to the online modality. Participant recruitment was high at the beginning of the study - 32 total participants completed session one. However, only 21 participants returned and successfully completed session two. In addition, very few control (3) and higher proficiency (7) participants were successfully recruited, which made comparisons of data across groups difficult. A highly proficient group was unfortunately not included in the study. Adding such a group would have been useful for both between-group comparisons and online experimental effectiveness; a lack of L2-on-L1 effects from a highly proficient group may have uncovered further problems with the online modality.
Conclusions

In summary, we have shown that less proficient L2 learners are able to become more sensitive to L2 words, and they are able to access the meanings of these words, even when learning in an online setting. However, several questions remain unanswered. First, we cannot provide unequivocal evidence that L2 meaning was accessed without mediation through the L1. While some participants displayed no semantic interference on the translation recognition task, we cannot be certain that L2 meaning was accessed directly without further comparisons to shorter SOAs. Next, the current study did not reveal any facilitative L2-on-L1 effects during language comprehension. While these results are disappointing, prior studies using more precise measurements have shown that facilitative affects are indeed possible during both comprehension (Bice & Kroll 2015) and production (Higby et al. 2019), providing hope for future studies post-pandemic. Lastly, the current study has illustrated the utility of longitudinal studies and the fascinating capabilities of the human mind during L2 development. Despite unforeseen and challenging remote circumstances, L2 learners can continue to grow and develop their second language abilities.

Appendix 1

Extended Participant Questionnaire
Adapted from (Giraldez-Elizo 2020; Parafita Couto et al., 2016; Torres, 2013; Mahn, 2003)

(0) In which Spanish course are you currently enrolled in?

- Spanish 1110
- Spanish 2110

(1) How old are you?
(2) Do you identify yourself as
a. Female
b. Male
c. Non-Binary
…Choose not to disclose.

(3) Do you have any language impairments?

(4) What languages did you learn at home from parents or other caretakers?
List some options …

1. Spanish
2. English
3. Both Spanish and English
4. Other (please identify)…

(5) What languages other than Spanish have you studied in formal settings?
1. French
2. Portuguese
3. Mandarin
4. Other (Please specify)

(6) What languages other than English do you use on a regular basis?
1. French
2. Portuguese
3. Mandarin
4. Other (Please specify)

(7) Have you lived or studied in a Spanish speaking country for more than three months?
Yes

No

(7ª) If Yes for (7), where did you live or study? For how long?

a. Less than a month
b. 3-6 months
c. 9 months to 1 year
d. More than 1 year
e. Between a year and 5 years
f. NA

(7b) If Yes for (7), what is the highest level of education you completed in that country?

c. Junior High or equivalent
c. High School or equivalent
c. Bachelor’s Degree, Diploma of Higher/Further Education, or equivalent
c. Master’s Degree, Doctorate, or equivalent
c. None of the above

(8) Have you studied in a bilingual education, immersion, or dual language program (a school where you learned Spanish and English at the same time)?

c. Yes
c. No
c. Other (Please specify)

(9) Which language(s) did your mother speak to you while you were growing up (if applicable)?

c. Spanish
(10) Which language(s) did your father speak to you while you were growing up (if applicable)?
   c Spanish
   c English
   c Spanish & English
   c Other (Please specify) ……………………………
   c N/A

(11) Which language(s) did any other guardian or caregiver (i.e. grandmother, grandfather, aunt, cousins, siblings) speak to you while you were growing up (if applicable)?
   c Spanish
   c English
   c Spanish & English
   c Other (Please specify) ……………………………
   c N/A

(12) Through which language(s) were you predominantly taught at primary school?
   c Spanish
   c English
   c Spanish & English
   c Other (Please specify) ……………………………

(13) Through which language(s) were you predominantly taught at secondary school?
   c Spanish
   c English
(14) In your everyday life, do you speak both English and Spanish with any of the following people? (You can select more than one answer)

- c Friend
- c Partner
- c Family member
- c Community member
- c N/A

(15) In your everyday life, do you speak Spanish with any of the following people? (You can select more than one answer)

- c Friend
- c Partner
- c Family member
- c Community member
- c N/A

(16) Please, click the percentage of Spanish you think you were exposed to in the following age periods: (Table will be adapted for an online format)

Example:

<table>
<thead>
<tr>
<th>Age periods</th>
<th>Percentages of exposure of Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 % (few words)</td>
<td>25% (Sometimes)</td>
</tr>
<tr>
<td>0-3 years old</td>
<td>i</td>
</tr>
<tr>
<td>4-5 years old</td>
<td>i</td>
</tr>
<tr>
<td>6-10 years old</td>
<td>i</td>
</tr>
<tr>
<td>10-13 years old</td>
<td>i</td>
</tr>
<tr>
<td>14-18 years old</td>
<td>i</td>
</tr>
<tr>
<td>Above 18</td>
<td>i</td>
</tr>
</tbody>
</table>

Please fill in table below
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<td>Above 18</td>
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</tbody>
</table>

ACTFL Can Do Statement Questions: Proficiency levels will not be visible to participants. Listening, Reading, Writing, Speaking

Indicate how much do you agree with the following statements about your Spanish level.

**Novice Mid**

(17) *I can identify names of classes and their locations on a class Schedule* (Novice Mid Reading)

   a) Yes I can do this with confidence
   b) Yes I can do this
   c) I still need work on this

(18) I can present information about myself, my interests and my activities using a mixture of practiced or memorized words, phrases and simple sentences *(Novice Mid Speaking)*

(19) I can understand directions for setting the table (Novice Mid Listening)

(20) I can tweet my opinion about a new movie in response to other tweets (Novice Mid Listening)

**Novice High**

(21) *I can understand some facts about the weather especially when weather symbols are used.* (Novice High Listening)

(22) *I can identify some written elements of a classroom, a school schedule, or levels of schooling.* (Novice High Reading)

(23) I can ask for directions when I’m lost. (Novice High Speaking)

(24) I can make plans for a picnic with others via text messages. (Novice High Writing)

**Intermediate Low**
(25) I can follow simple cooking directions from a YouTube video. (Intermediate Low Listening)

(26) I can have a conversation with others to determine how we should plan to spend our spring break. (Intermediate Low Speaking)

(27) I can exchange descriptions with my friend from Spain to agree on the best places to hike in the US. (Intermediate Low Writing)

(28) I can understand a text message from a friend about an assignment. (Intermediate Low Reading)

Intermediate Mid

(29) I can understand product information in an ad on TV. (Intermediate Mid Listening)

(30) I can understand the personal messages exchanged over text or social media. (Intermediate Mid Reading)

(31) I can interact with my friends to plan an ideal date. (Intermediate Mid Speaking)

(32) I can write a simple story about a recent trip, project or childhood memory (Intermediate Mid Writing)

Intermediate High

(33) I can understand information provided in a travel guide about an historical site. (Intermediate High Reading)

(34) I can follow the major events of a traveler’s experience in a Youtube video. (Intermediate High Listening)

(35) I can give a short speech about my goals for the future. (Intermediate High Speaking)

(36) I can write a description of an event that I participated in or witnessed for a newsletter. (Intermediate High Writing)

References


